

Robots and Capabilities Classification

Public Forum

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Outline

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- What is an Ontology?
- Benefits of Having An Ontology
- Ontology Infrastructure
 - OWL/OWL-S
 - Protégé
- Ontology Organization
 - Structural Characteristics
 - Functional Capabilities
 - Operational Considerations
- The Robot Ontology
- What's Next

Goal

- To develop and begin to populate a neutral knowledge representation capturing relevant information about robots and their capabilities to assist in the development, testing, and certification of effective technologies for search and rescue robot systems
- Future efforts will develop knowledge representations for building and collapse types (to be discussed in the next presentation)

What Is An Ontology?

- “a specification of a conceptualization”
- Ontologies represent key concepts, their properties, their relationships, and their rules and constraints.
- Ontologies often focus more heavily on the *meaning* of concepts as opposed to terms that are used to represent them
- Vocabulary + Structure = Taxonomy
- Taxonomy + (Relationships and Constraints) = Ontology
- Ontologies:
 - Bring meaning to data
 - Make different relationships explicit
 - Allows computers to use semantic relationships

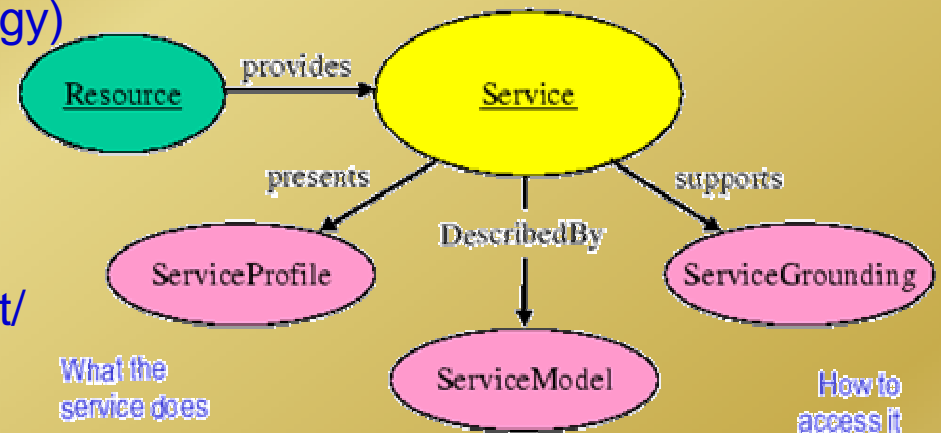
Benefits of Having An Ontology

- Less ambiguity in term usage & understanding
- Explicit representation of all knowledge, without hidden assumptions
- Conformance to commonly-used standards
- Availability of the knowledge source to other domains outside of urban search and rescue
- Availability of a wide variety of tools (reasoning engines, consistency checkers, etc.)

Ontology Infrastructure: OWL / OWL-S

- OWL

- W3C Recommendation 10 February 2004
- Defines terms commonly used in creating a model of an object or process (i.e., an ontology)
 - Class/Subclass
 - Property/Subproperty
 - Property Restrictions
 - Individual
- <http://www.w3.org/2001/sw/WebOnt/>

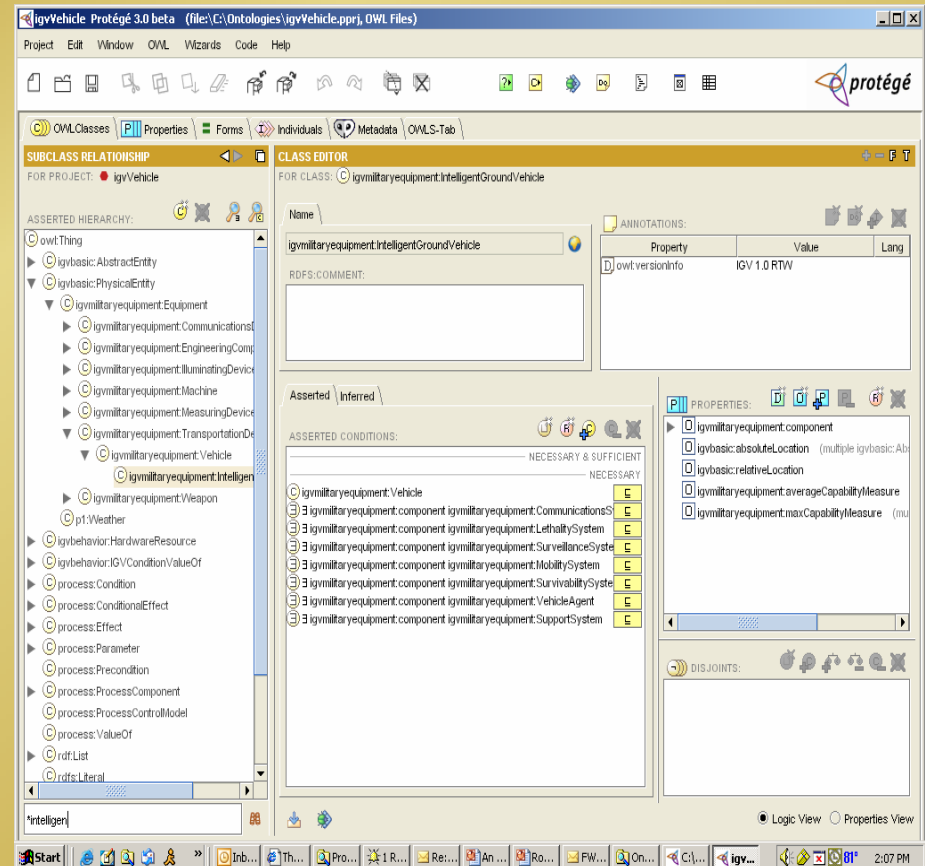


- OWL-S

- An OWL-based Web service ontology, which describes the properties and capabilities of services in an unambiguous, computer-interpretable form.
- Developed by the DARPA Agent Markup Language (DAML) Program
- OWL-S is an upper ontology intended to be extended to meet specific applications
- <http://www.daml.org/services/owl-s/1.0/>

Ontology Infrastructure: Protégé

- An open source ontology editor developed at Stanford University.
- Supports: Class and property definitions and relationships, Property restrictions, Instance generation, Queries
- Accommodates plug-ins (actively being developed)
- <http://protege.stanford.edu/download.html>



Related Knowledge Representation Efforts

- Efforts at University of Electro-Communications in Tokyo, Japan to determine the information requirements for a US&R ontology
- Efforts at SPAWAR to develop a Mobile Robot Knowledge Base
- Efforts at CRASAR to develop taxonomies for robot failures and issues pertaining to social interactions between robots and humans

Initial Ontology Organization*

- Structural Characteristics – describes the physical and structural aspects of a robot
- Functional Capabilities – describes the behavioral features of the robot
- Operational Considerations – describes the interactions of the robot with the human and the interoperability with other robots

*Leveraged from “Robot Description Ontology and Disaster Scene Description Ontology: Analysis of Necessity and Scope in Rescue Infrastructure Context”
performed by The University of Electro-Communications, Tokyo Japan

Structural Characteristics

- Size
- Weight
- Tethering
- Power Source
- Locomotion Mechanism (wheeled, walking, crawling, jumping, flying, etc.)
- Sensors (camera, FLIR, LADAR, SONAR, GPS, Audio, Temperature Sensor)
- Processors
- ...

Functional Capabilities

- **Locomotion Capabilities** (e.g., max speed, max step climbing, max slope climbing, etc.)
- **Sensory Capabilities** (e.g., min visibility level, map building capability, self localization, system health, etc.)
- **Operational Capabilities** (e.g., working time, setup time, max force available to push, MTBF, MTBM, required tools for maintenance, run time indicator, sustainment (spares and supplies), etc.)
- **Weather Resistance** (e.g., max operating temp, max submergability level, etc.)
- **Degree of Autonomy** (e.g., joint level dependency, drive level dependency, navigation level dependency, etc.)
- **Rubble Compatibility** (e.g., ability to historically operate well in certain terrains)
- **Communications** (e.g., comm media, comm channel frequency, content standards, information content, comm locking, comm encryption)
- ...

Operational Considerations

- Human Factors (operator ratio, initial training, proficiency education, acceptable usability, auto-notification, display type, packaging size)
- Intra-Group Interaction (i.e., interaction with other similar robots)
- Inter-Group Interaction (i.e., interaction with other 3rd party robots or computers)

ontology6 Protégé 3.1 beta (file:\C:\My%20Documents\dhs\ontology6.ppr, OWL Files (.owl or .rdf))

File Edit Project OWL Code Window Tools Help

OWLClasses Properties Forms Individuals Metadata

SUBCLASS RELATIONSHIP

For Project: ontology6

Asserted Hierarchy

- owl:Thing
 - AbstractConcepts
 - AccessibilityAndObservability
 - Capability
 - CommunicationCapability
 - LocomotionCapability
 - OperationalCapability
 - RubbleCompatibillity
 - SensoryCapability
 - TaskDegreeOfAutonomy
 - WeatherResistance
 - HumanFactorsCapability
 - CommunicationChannel
 - CommunicationMedia
 - CommunicationSecurity
 - ComputerComponent
 - DisasterCause
 - GeologicalFeaturesOntologyStub
 - InformationStub
 - InputMethod
 - LocomotionMechanism
 - LocomotionMode
 - LocomotionType
 - MaterialOntologyStub
 - PowerSourceStub
 - Robot**
 - ScenarioStub
 - SensorStub
 - SiteClassification
 - UserInterface

CLASS EDITOR

For Class: Robot (instance of owl:Class)

Name: Robot

SameAs DifferentFrom

rdfs:comment

a mechanism with locomotion and sensing capability which a human user may interact with from a remote location

Annotations

Property	Value	Lang
rdfs:comment	a mechanism with locomotor...	

Properties

Asserted Inferred

Asserted

NECESSARY & SUFFICIENT

NECESSARY

owl:Thing

- hasCommunicationCapability (multiple CommunicationCapability)
- hasHumanFactorsCapabilities (single HumanFactorsCapability)
- hasLocomotionCapability (single LocomotionCapability)
- hasLocomotionMechanism (multiple LocomotionType)
- hasOperationalCapability (single OperationalCapability)
- hasPowerSource (multiple PowerSourceStub)
- hasProcessor (multiple Processor)
- hasRubbleCompatibility (single RubbleCompatibility)
- hasSensor (multiple SensorStub)
- hasSensoryCapability (single SensoryCapability)
- hasSize (single Size)
- hasTaskDegreeOfAutonomy (multiple TaskDegreeOfAutonomy)
- hasTethering
- hasWeatherResistance (single WeatherResistance)
- hasWeight (single Weight)

Disjoints

Logic View Properties View

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CLASS EDITOR

For Class: LocomotionCapability (instance of owl:Class)

Name SameAs DifferentFrom

LocomotionCapability

rdfs:comment

Annotations

Property	Value	Lang
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Asserted Inferred

Asserted

NECESSARY & SUFFICIENT

NECESSARY

Capability

Properties

- hasLocomotionMode
- hasMaximumBackwardSpeed (single xsd:float)
- hasMaximumForwardSpeed (single xsd:float)
- hasMaximumSlopeClimbingCapability (single xsd:float)
- hasMaximumStepClimbingCapability (single xsd:float)
- hasRecoveryFromTurnedOverPosture (single xsd:boolean)

Disjoints

Logic View Properties View

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CLASS EDITOR

For Class: OperationalCapability (instance of owl:Class)

Name SameAs DifferentFrom

OperationalCapability

rdfs:comment

Annotations

Property	Value	Lang
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Properties

- hasMaximumForceToPush (single xsd:float)
- hasMaximumPowerConsumption-WhenIdle (single xsd:float)
- hasMaximumPowerConsumptionRate-DuringOperation (single xsd:float)
- hasMinimumPowerConsumption-DuringOperation (single xsd:float)
- hasMinimumPowerConsumption-WhenIdle (single xsd:string)
- hasMTBF (single xsd:float)
- hasOperationDuration (single xsd:float)
- hasRangeofOperation (single xsd:string)
- hasSelfSustainingSparesAndSupplies (single xsd:float)
- hasSetupTime (single xsd:float)
- requiresSpecialToolsForMaintenance (single xsd:boolean)

Disjoints

Logic View Properties View

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CLASS EDITOR

For Class: SensoryCapability (instance of owl:Class)

Name: SensoryCapability

SameAs DifferentFrom

rdfs:comment

Annotations

Property	Value	Lang
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Properties

- hasBiologicalEntityIdentification (single xsd:boolean)
- hasEnvironmentLifeSupportEstimationCapability (single xsd:boolean)
- hasHumanBodyIdentification (single xsd:boolean)
- hasHumanVoiceIdentification (single xsd:boolean)
- hasMapBuildingCapability (single xsd:float)
- hasMinimumVisibilityLevel (single xsd:float)
- hasRobotIdentification (single xsd:boolean)
- hasSelfHealthSensing (single xsd:boolean)
- hasSelfLocalization (single xsd:float)

Disjoints

Logic View Properties View

Robot Ontology Metrics

- 230 classes
- 245 slots (attributes)
- 180 instances

What's Next

- Continue to provide greater detail in the robot ontology
- Explore leveraging other standards efforts and ontologies
 - Sensors
 - Power Source
 - Materials
 - Environment
- Continue to incorporate the requirements from the requirements workshops into the ontology
- Explore the incorporating reasoning engines
- Develop ontologies for building and collapse types